

UPPER LLANDEILO TRILOBITES FROM THE BERWYN HILLS, NORTH WALES

by A. R. MACGREGOR

ABSTRACT. Sixteen species in twelve genera are described including the following new species, *Bumastus powisensis*, *Marrolithus magnificus*, *M. lirellatus*, *Atractopyge sedgwicki*, *A. williamsi*, and *Metopolichas contractus*. The fauna was collected from three small inliers of Llandeilo rocks in the Berwyn Dome, North Wales. There is a large indigenous element in the fauna, and an exotic element, in which two species appear to be from the Appalachian province, and one might possibly be from the Bohemian province. Two species are at present cryptogenetic.

THIS paper is a systematic account of the trilobite fauna found in the three inliers of Llandeilo rocks in the Berwyn Hills, together with a discussion of that fauna. The succession within the Llandeilo rocks has been outlined in a previous paper (MacGregor 1961).

The placing of the fauna in the Upper Llandeilo is based, particularly, on the very great abundance of *Marrolithus favus* in the rocks, which both Williams (1948, p. 87) and Whittard (1956, p. 57) regard as a reliable indication of the Upper Llandeilo. The rarity in the Berwyns of marrolithids, known from Lower or Middle Llandeilo beds elsewhere, may be taken as confirmation of this, though Whittard expressed doubts on the zonal value of most other species of *Marrolithus*. Of the other established species, *Basilicus tyrannus*, *Ogygiocarella debuchii*, and *Flexicalymene cambrensis* are all known right through the Llandeilo and can, therefore, only point to a general Llandeilo age. *Marrolithoides arcuatus* s.s. is found in the *N. gracilis* graptolite zone of the Caradoc. The remainder of the fauna consists of new species not yet known elsewhere.

The material on which the paper is based was collected by the author, and is preserved as internal and external moulds, except for a small number of specimens in which shell material remains. All the figured material has been presented to the Sedgwick Museum, Cambridge, and bears the prefix A before the registered numbers. A small number of specimens referred to, or in one case figured, from other sources are prefixed as follows: GSM, Geological Survey Museum; BM, British Museum (Natural History); OUM, University Museum, Oxford; and followed by the registered number. The terminology used in the paper is that of the Treatise on Invertebrate Paleontology, Section O. Arthropoda I, except that the terms 'fixed cheeks' and 'free cheeks' have been used in preference to 'fixigenae' and 'librigenae'.

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versity, and the Geology Department, Birmingham University. The writer is also indebted to the Carnegie Trust for the Universities of Scotland for a grant towards the cost of the plates.

SYSTEMATIC DESCRIPTIONS

Family ASAPHIDAE Burmeister 1843
Subfamily ASAPHINAE Burmeister 1843
Genus BASILICUS Salter 1849
Basilicus tyrannus (Murchison 1839)

Plate 116, figs. 1-5

1839 *Asaphus tyrannus* Murchison, p. 648, pl. 24, fig. 4, pl. 25, fig. 1.

Material. Some forty specimens of cranidia, free cheeks and pygidia.

Localities. Widespread in all three inliers; common at SJ 12272807, 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Ash, Limestone, and Calcareous Shale.

Description. *Cephalon:* rather more than twice as broad as long, evenly convex outline in front, more strongly curved laterally, drawn into short narrow genal spines about half length of rest of cephalon. Gently convex transversely and longitudinally, most strongly so over anterior glabellar lobe in both directions. Posterior margin straight, slightly convex backwards behind glabella. Glabella with prominent broadly clavate anterior lobe extending almost to anterior margin and about two-thirds length of glabella; tapering posteriorly. Remaining lobes ill defined and low; a pair of oblique low lobes extends outwards to join palpebral lobes, posterior lobes little more than a slight ridge parallel to posterior margin. Anterior pair of glabellar furrows behind anterior lobe converge backwards, become shallower and meet in mid-line. Next pair of furrows run straight inwards from a point level with posterior end of the eye; appear to join anterior pair about mid-line. Occipital furrow very shallow, especially in mid-line; continued laterally by posterior border furrow. Axial furrows merge with preglabellar furrow, are broad and ill defined as they diverge round anterior glabellar lobe; they become shallower, rise up to pass palpebral lobes; here they converge slightly before diverging again and become a little deeper as they drop down to posterior margin. Palpebral lobes raised above remainder of cheeks, but not as high as anterior glabellar lobe; anteriorly fixed cheek merges with narrow preglabellar field and carries a shallow continuation of preglabellar furrow. Free cheeks gently sloped outwards with large holochroal eyes standing markedly above cheeks, from which separated by shallow furrow. Faint border furrow dies out towards genal spine. Posterior border furrow also dies out towards genal spine. Genal spine sharply pointed, confluent with lateral margin of cephalon. Doublure visible on a broken free cheek, shows fine terrace lines parallel to lateral margin. Facial sutures run forward and outwards from palpebral lobes at about 50° to long axis of cephalon, so that breadth across anterior of cranidium is half as much again as that across palpebral lobes. Sutures run in this direction almost to margin of cephalon before turning to meet margin at approximate right angles. Behind palpebral lobes sutures run fairly straight outwards and backwards at about 30° to posterior margin, this angle increasing to about 45° just before suture reaches margin.

Hypostoma and thorax: not known from the Berwyns.

Pygidium: half as wide again as long, parabolic in outline, gently convex anteriorly. Convex transversely, sharply dropping to border. Axis anteriorly about one-fifth total width, tapering backwards more sharply at first so that it is about half this width about one-third way back; behind this, becomes almost parallel-sided and ends in a swollen tip some distance from posterior margin and standing above border. Axis gently convex, transversely at front, becoming more so backwards until strongly convex at tip. At least fourteen axial rings present; ring furrows shallow in mid-line, deepening outwards, but becoming shallow again before they join axial furrows. Axial furrows steeper-sided against axis than against pleurae, not sharp or deep. Pleurae, ten or eleven on each side, separated by rounded concave interpleural furrows. Pleural furrows not seen. Pleurae and furrows die out towards weakly concave border. Pleurae more strongly convex towards border, becoming more marked backwards especially adjacent to tip of axis. Border smooth apart from terrace lines arranged almost at right angles to axis. These seem to die out on to pleurae, swing forward slightly on more anterior parts of border. Doublure extends certainly beneath border, where it carries terrace lines parallel to margin of pygidium, and it may extend farther.

Remarks. This species can be readily distinguished from *B. peltastes* Salter even in isolated cranidia, free cheeks, and pygidia (Salter 1864, p. 152); though present at Llandeilo, that species is unrecorded from the Berwyn Hills.

Subfamily OGYGIOCARIDINAE Raymond 1937
Genus OGYGIOCARELLA Harrington and Leanza 1957
Ogygiocarella debuchii (Brongniart 1822)

Plate 116, fig. 14

1822 *Asaphus de Buchii* Brongniart, t. 2, fig. 2.

1865 *Ogygia buchi*; Salter, p. 125, pl. 14, figs. 1-7, pl. 15, figs. 1-6.

Material. One broken pygidium.

Locality. SJ 12852846, 730 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llanrhaiadr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Description. *Pygidium*: outline parabolic, very gently convex, almost flat, slightly bent down peripherally; length/breadth: seven-eighths on this single specimen; axis narrow, occupying about one-fifth total breadth at anterior, tapering backwards rapidly at first, less so towards posterior so that almost parallel-sided at tip. Axis flattened anteriorly, little higher than pleurae, but gradually rising backwards to tip, which stands distinctly above pleurae though still low. At least eight axial rings, which become less distinct towards rear; ring furrows shallow, also becoming less distinct towards rear. Axial furrows shallow and narrow at front, becoming broader and slightly deeper backwards. Eleven pleurae becoming successively weaker backwards, flat with distinct interpleural furrows, which coincide with axial ring furrows, not quite parallel-sided, expanding slightly outwards, straight-edged proximally and curving backwards distally. Pleural furrows reach almost to axial furrows and continued on axial rings by faint furrows, do

not reach so far towards margin and are much shallower than interpleural furrows. Marginally, weak concentric ridging developed, but this may be impressed from the doublure due to crushing.

Remarks. The rarity of the species in the Berwyns is remarkable in view of its abundance in the Llandeilo strata of almost all other areas of outcrop, but elsewhere the species commonly is restricted to finer-grained deposits.

Family ILLAENIDAE Hawle and Corda 1847

Subfamily BUMASTINAE Raymond 1916

Genus BUMASTUS Murchison 1839

Bumastus powisensis sp. nov.

Plate 116, figs. 6-10

Derivation of name. From Powis, the district of Wales in which the southern part of the Berwyn Hills lies.

	<i>Length</i> <i>mm.</i>	<i>Breadth</i> <i>mm.</i>
<i>Holotype.</i> A 46919, Plate 116, fig. 6. Internal mould of cranium.	14	23
<i>Paratypes.</i> 1. A 53008, Plate 116, figs. 7, 8. Broken internal mould of cranium	13	22 est.
2. A 53009, Plate 116, figs. 9, 10. External mould of hypostoma	5	7

Material. One whole and seven broken cranidia and one hypostoma.

Type localities. Holotype from SJ 07292634, 100 yards north of Llwyn-Onn Farmhouse, 3 miles west of Llanrhaidr-ym-Mochnant; paratype 1 from SJ 12582848, roadside quarry, 450 yards south-south-west of Pen-y-graig, 1½ miles north of Llanrhaidr-ym-Mochnant; paratype 2 from SJ 12172815, 200 yards north-north-west of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Ash, Limestone, and Calcareous Shale.

Diagnosis. Cranidium much wider than long, the eyes set far back and the axial furrows weak but long.

Description. *Cranidium:* much wider than long, gently convex transversely and longitudinally, but bent down vertically at front and less steeply at back. Glabella separated from fixed cheeks by weak but long axial furrows; broadest between fossulae, narrowest between palpebral lobes and broadening again slightly to base. Axial furrows shallow throughout, curved concave outwards, ending forwards in fossulae, which are a little deeper than furrow and which have a small central pustule; behind, end in pit at junction with shallow, narrow, occipital furrow, which is continued laterally by a broader, deeper posterior border furrow. Fixed cheeks about half breadth of glabella with well-defined palpebral lobes, the front of which is only one-third way from posterior to anterior margin. Cheeks slope down and back behind palpebral lobes towards posterior margin. Facial sutures run forward from palpebral lobes almost parallel to axial furrows at about 30° to long axis and then turn gradually inwards; just before the anterior of the cranium starts to steepen, sutures turn inwards, then pass over the steep margin, and are lost sight of just outside a line through the fossulae. Posterior

branches run back from palpebral lobe, swing out at about 45° to long axis, and only just short of posterior border do they swing more nearly straight back again to cut border. Surface of internal moulds smooth except near anterior margin; external moulds show surface covered with small irregular pits except anteriorly, where, as in internal moulds, concentric ridges run right across cranidium parallel to margin; these occasionally branch, are most strongly developed at margin and become fainter away from it and do not occur at more than 3 mm. from the margin; less distinct on internal moulds.

Hypostoma: subtriangular, width across anterior wings greater than length. Anteriorly gently rounded, posteriorly more strongly so; anterior wings about quarter way back, lateral margins continuous with posterior margin. Middle body: anterior lobe large, moderately swollen, more convex transversely than longitudinally; posterior lobe small,

EXPLANATION OF PLATE 116

Plates 116–18 are mainly of natural external and internal moulds and of plastic moulds made from these. They are unretouched, but the specimens were lightly coated with ammonium chloride before being photographed.

Figs. 1–5. *Basiliscus tyrannus* (Murchison). 1, From 80 yards north of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, A 53006, internal mould of incomplete cranidium, $\times 1.5$. 2, 4, From 960 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llanrhaidr-ym-Mochnant. 2, A 46915, free cheek, $\times 1.5$. 4, A 53007, internal mould of pygidium, $\times 1.5$. 3, From 200 yards north-north-west of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, A 46916, internal mould of pygidium, $\times 1.5$. 5, From scree 350 yards east of Llwyn-Onn, 3 miles west of Llanrhaidr-ym-Mochnant, plastic mould of A 46917, external mould of pygidium, $\times 0.75$.

Figs. 6–10. *Bumastus powisensis* sp. nov. 6, From 100 yards north-east of Llwyn-Onn, 3 miles west of Llanrhaidr-ym-Mochnant, A 46919, holotype, internal mould of cranidium, $\times 2$. 7, 8, From 960 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llanrhaidr-ym-Mochnant, dorsal and side views of A 53008, paratype 1, internal mould of incomplete cranidium, $\times 2$. 9, 10, From 200 yards north-north-west of Nant, 1 mile north of Llanrhaidr-ym-Mochnant. 9, A 53009, paratype 2 external mould of hypostoma, $\times 4.5$. 10, Plastic mould of A 53009, $\times 4.5$.

Figs. 11–13. *Proetidella* sp. 11, 12, From 80 yards north of Nant, 1 mile north of Llanrhaidr-ym-Mochnant. 11, A 53010, internal mould of pygidium, $\times 4$. 12, A 46911, free cheek, $\times 4$. 13, From 200 yards north-north-west of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, A 46912, internal mould of incomplete cranidium.

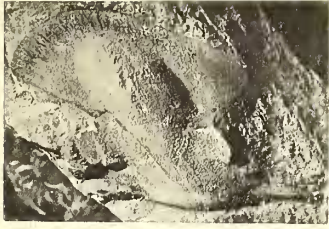
Fig. 14. *Ogygiocarella debuchii* (Brongniart). From 730 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llanrhaidr-ym-Mochnant, A 46914, internal mould of incomplete pygidium, $\times 1.5$.

Figs. 15, 16. *Marrolithoides* sp. from 80 yards north of Nant, 1 mile north of Llanrhaidr-ym-Mochnant. 15, Plastic mould of A 53011, incomplete external mould of cephalon, $\times 2$. 16, Plastic mould of A 46909, incomplete internal mould of cephalon, $\times 2$.

Figs. 17–20. *Marrolithus lirellatus* sp. nov. 17, 19, From 80 yards north of Nant, 1 mile north of Llanrhaidr-ym-Mochnant. 17, A 46906, paratype 1, incomplete brim of cephalon showing ventral lamella, $\times 2$. 19, A 46907, paratype 2, internal mould of cephalon, $\times 2$. 18, From 100 yards north-east of Llwyn-Onn, 3 miles west of Llanrhaidr-ym-Mochnant, plastic mould of A 53012, holotype, external mould of incomplete cephalon, $\times 2$. 20, From 730 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llanrhaidr-ym-Mochnant, plastic mould of A 46908, external mould of incomplete cephalon, $\times 2.5$.

Fig. 21. *Marrolithoides* cf. *arcuatus* Whittard, from 80 yards north of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, plastic mould of A 46910, external mould of cephalon, $\times 2$.

Fig. 22. ? *Primaspis* sp. from 200 yards north-north-west of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, A 46913a, internal mould of pygidium, $\times 6$.



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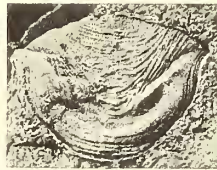
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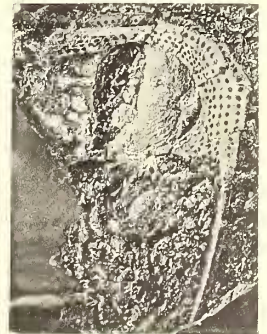
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arcuate, slightly raised into weak maculae laterally. Median furrow strong in front of maculae and out to anterior wings, but weaker centrally, almost disappearing in mid-line. Lateral furrow broad and shallow after leaving median furrow, continuous with posterior furrow, which is also broad but rather deeper. Lateral and posterior border slightly raised outside furrow. Anterior wings short, almost right angles, rising sharply from lateral furrows before flattening out to be continuous with anterior lobe of middle body. Ornament of fine, roughly concentric grooves parallel to posterior and lateral margins; they branch and rejoin, most numerous in mid-line, joining and decreasing in numbers laterally; seven to eight grooves per mm.

Free cheeks, thorax and pygidium: not known.

Remarks. The only species closely resembling this is *B. fronto* Troedsson (1929) from the Upper Ordovician of Greenland, though that species shows more coarsely spaced ornament. The proportions of the cranidium are remarkably similar, but the cranidium of this species is usually about half the size of *B. fronto*, though one specimen of *B. powisensis* resembles *B. fronto* in size.

Family PROETIDAE Salter 1864
Subfamily PROETIDELLINAE Hupé 1953
Genus PROETIDELLA Bancroft 1949

Proetidella sp.

Plate 116, figs. 11–13

Material. Six cranidia, five free cheeks and one pygidium.

Localities. SJ 12272807, 80 yards north of Nant; SJ 12172815, 200 yards north-north-west of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Description. *Cephalon*: approximately semicircular, convex transversely and less so longitudinally, approximately twice as broad as long. Continuous border marked off by furrow laterally and anteriorly. Glabella, just under one-third width and two-thirds length of cephalon; one-third as long again as broad, contracts slightly anteriorly, rounded in front, rises from neck furrow, very gently convex, slopes down anteriorly where it drops sharply into anterior furrow; evenly convex transversely, drops more steeply into axial furrows. Preglabellar field gently upturned, a little higher than lateral border, preglabellar furrow more rounded and broader than lateral furrow. Glabellar furrows very poorly developed and not always seen; a pair of very faint anterior furrows occasionally seen to slope backwards and inwards, inclined to axis at 45° and lying about two-fifths way back. Posterior pair of furrows curved and slope inwards and then backwards from a little more than half-way back. Lobes formed by these, roughly triangular, joined to rest of glabella posteriorly, each a little less than one-third width of base of glabella. Occipital furrow deep and swings forward to mid-line at postero-lateral angles of glabella. Occipital ring two-thirds length at sides that it is in mid-line, flattened longitudinally, gently arched transversely and lower than back of glabella; occipital node and lobes lacking. Fixed cheeks very narrow. Palpebral lobes far back, extending almost to posterior glabellar lobes; they are half the length of and only slightly lower than

glabella. Facial sutures run almost straight forward from palpebral lobes just outside axial furrows before cutting margin of cephalon almost at right angles; posterior branches run straight into posterior border furrows, then diverge strongly to cut posterior margin at about 30° half-way from axial furrow to outside lateral margin. Free cheeks rounded anteriorly, outer margin curved, becoming almost parallel to axis before passing into genal spines. Border appears to be flattened. Free cheeks quite strongly convex, bent down laterally and less strongly anteriorly. Genal angle produced into flattened triangular spine on to which lateral border furrow passes. Posterior border furrow extends across free cheek to join lateral border furrow in front of genal spine. Posterior border narrow and strongly convex. A furrow rises from posterior border furrow near axial furrow, passes round outer side of eye and dies out forwards. Eye almost semi-circular, sub-reniform, about half length of glabella, lies close to axial furrow, elevated above level of rest of free cheek.

Thorax: not known.

Pygidium: outline curved, just over twice as wide as long, slightly flattened across posterior; axis strongly convex with four clear axial rings and a nub behind these, tapers posteriorly for about two-thirds of length of pygidium, and is one-third of the breadth at anterior. Axial furrows shallow. Four pairs of pleurae present, all flattened and bent down at margin, anterior pair better defined, and have weak interpleural ridge at outer ends.

Remarks. This early British proetid species agrees with *Proetidella* in the form of the fairly long, preglabellar field and the position of the eyes, which lie close to the axial furrows and far back, being just in front of the posterior border furrows; the furrow is just lateral to the eyes and on the cheek. The form of the pygidium is also similar, though there are fewer axial rings in this species than in *P. fearnsidesi*. From the contemporary *Proetus* (?) *blandi* Cooper and *Proetus* (s.l.) *strasburgensis* Cooper from Virginia, this species differs in the form of the preglabellar field, where there is a much less sharp division between the furrow and ridge. The pygidium of this species is very similar to that of *P. (?) blandi*, however. *Ogmocnemis* from the Whittery Shales of Shropshire is markedly different, the eyes being much farther forward.

Family DIMEROPYGIDAE Hupé 1953

Genus DIMEROPYGE Öpik 1937

Dimeropyge sp.

Plate 118, figs. 20, 21

Material. One pygidium.

Locality. SJ 12272807, 80 yards north of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Diagnosis. Pygidium with high vertical border beneath the pleural spines and no median indentation in the margin behind the axis.

Description. *Pygidium*: with four segments, semicircular; axis raised and rounded, higher than pleurae, sloping down backwards. Axis with three rings, and a terminal

piece seen as a pair of nodes behind third ring; does not reach posterior margin; about one-third total width at anterior; with articulating half ring. All three rings separated by well-defined transverse furrows; second and third rings with a median depression, faint on second, stronger on third and separating axis behind this into a pair of nodes. Axial furrows well defined, broader and shallower than axial ring furrows, deepen into pits at junctions with these; shallowest at posterior end. Four pairs of pleurae separated by sharp interpleural furrows continuous with axial ring furrows; weak pleural furrows near ends of pleurae. Interpleural furrows shallowest near axial furrows, deepen outwards. Pleurae broaden outwards to a series of pleural spines, then bent down sharply to a continuous vertical border. Interpleural furrows die out on this border, not reaching the bottom of it. Fourth pleurae meet in mid-line and run back almost parallel to axis, but behind it. Remaining pleurae curved to an increasing degree from front to back. Ornamentation, surface tuberculate everywhere except in furrows and on vertical border. Furrows smooth as is vertical border except for terminations of interpleural furrows. Tubercles are unevenly developed, largest round periphery overhanging border, two at end of each pleura. Larger tubercles also present on pleurae next axial furrows, one on each of first three pairs, two on each of fourth pair. Tubercles over remaining surface are considerably smaller.

Remarks. There is no close resemblance to any of the species described by Sinclair (1946). This species differs from *D. spinifera* Whittington and Evitt in having shorter tubercles, but this may be due to inferior preservation. From *D. virginiensis* of the same authors this species differs in having a higher border, while the posterior margin is not indented behind the furrow, which splits the terminal part of the axis of the pygidium. This species differs from *D. minuta* (Nieszkowski) in the absence of this indentation and in having coarser ornament. *D. minuta* appears in the Kukruse of Estonia, equated by Jaanusson and Strachan (1954, p. 693) with the *gracilis* zone in the graptolite succession. *D. spinifera* and *D. virginiensis* occur in the Lincolnshire Limestone and Botetourt Formation of the Edinburg Limestone respectively. The occurrence of *D. spinifera* seems to be about contemporary with this species, while *D. virginiensis* and *D. minuta* are slightly younger. An eastward migration seems to be indicated, with the earlier *Dimeropygiella* Ross as a possible ancestor. This specimen is slightly larger than pygidia of either *D. spinifera* or *D. virginiensis*.

Family TRINUCLEIDAE Hawle and Corda 1847

Subfamily CRYPTOLITHINAE Angelin 1854

Genus MARROLITHUS Bancroft 1929

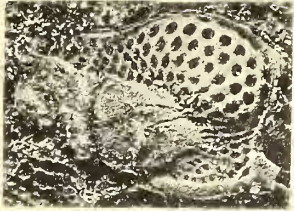
Remarks. It seems desirable that Whittard's (1956, pp. 27–29) nomenclature for the fringe formula on trinucleid brims should be adopted in the species of both *Marrolithus* and *Marrolithoides*, as it is applicable to almost all genera in the family. This still seems to be so, despite the fact that the system has one disadvantage when compared with Williams's system (1948, pp. 68–70). When noting the last radial row in which a concentric row of pits occurs, there are no difficulties in the E_1 and I_1 rows, but sometimes in the I_2 , and apparently almost always in the I_3 and subsequent rows, there is a loss of regularity, a breakdown of the concentric arrangement and possible introduction of adventitious pits. Thus it cannot with any certainty be said where a concentric row ends.

This makes the counting of pits laterally, i.e. beyond the angulation, in the more internal rows rather unreliable and therefore almost superfluous.

The nomenclature of the swollen area is dependent on an arbitrary delimitation of the pits within it. It was set up by Williams (1948, pp. 69–70) and was criticized by Whittard (1956, p. 51) who, however, was unable to provide a substitute or less subjective terminology. No satisfactory substitute is as yet forthcoming, but the following comments may prove useful. Although Williams states that pits on the slopes of the swollen areas should not be included in the pit count for the swollen areas, it is necessary to include pits some distance down the slopes to arrive at the counts obtained by both Williams and Whittard. To decide which pits on the slope are to be included is the most uncertain part of the procedure. Within the limitations of the system, it is possible to arrive at a fairly constant count for a specimen, based initially on counts on the holotypes. So far as pits in the I_1 row are concerned, the height above E_1 seems to be important. If the pit in I_1 is higher than the E_1 pit in the same radial row then it can be included in the swollen area. In the absence of a girder between the more internal rows, e.g. I_1 – I_2 or I_2 – I_3 , pits in the swollen area are less easily delimited.

EXPLANATION OF PLATE 117

- Figs. 1–3. *Marrolithus magnificus* sp. nov. From 730 yards north-west of Plas-yn-glyn, 1 mile north-east of Llanrhaiadr-ym-Mochnant. 1, Plastic mould of A 46902, holotype, external mould of incomplete cephalon, $\times 3$. 2, Plastic mould of A 53013, paratype 1, external mould of incomplete cephalon, $\times 3$. 3, Plastic mould of A 53014, paratype 2, external mould of incomplete cephalon, $\times 3$.
- Fig. 4. *Marrolithus inflatus maturus* Williams, from 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, A 46903, brim of cephalon and mould of genal spine, $\times 2$.
- Figs. 5–11. *Marrolithus favus* (Salter). 5, 6, 8, From 200 yards north-north-west of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant. 5, A 46901, external mould of cephalon, $\times 3$. 6, Plastic mould of A 46901, $\times 3$. 8, Anterior view of A 53016, incomplete cephalon, $\times 2$. 7, 9–11, From 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant. 7, Anterior view of A 53015, laterally compressed cephalon, $\times 2$. 9, A 53017a, internal mould of incomplete cephalon showing aberrant development of E_2 pits in antero-lateral corner of brim, $\times 3$. 10, Internal mould of pygidium, A 53018, showing muscle impressions on axis, $\times 4$. 11, Plastic mould of A 53019, external mould of pygidium, $\times 4$.
- Figs. 12–16. *Atractopyge williamsi* sp. nov. 12, From 200 yards north-north-west of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, A 53020, paratype 4, external mould of pygidium, $\times 6$. 13–16, From 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant. 13, A 53021a, paratype 7, internal mould of pygidium, $\times 4$. 14, 15, Normal and posterior views of plastic mould of A 46896, paratype 5, external mould of incomplete pygidium showing doublure, $\times 6$. 16, Plastic mould of A 46895, paratype 6, external mould of pygidium, $\times 6$.
- Figs. 17, 18. *Atractopyge sedgwicki* sp. nov. From 730 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llanrhaiadr-ym-Mochnant. 17, A 46897, holotype, external mould of incomplete cranidium, $\times 3$. 18, Plastic mould of A 46897, $\times 3$.
- Figs. 19–25. *Flexicalymene cambrensis* (Salter). 19–21, 23, From 200 yards north-north-west of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant. 19, A 53022, internal mould of hypostoma, $\times 5$. 20, 21, Side and normal views of A 53023, internal mould of incomplete cranidium, $\times 3$. 23, A 46898, incomplete cranidium showing shell ornament on glabella, $\times 3$. 22, From 960 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llanrhaiadr-ym-Mochnant, plastic mould of A 46900a, external mould of incomplete cranidium, $\times 3$. 24, 25, From 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, normal and posterior views of A 53024, internal mould of pygidium, $\times 3$.



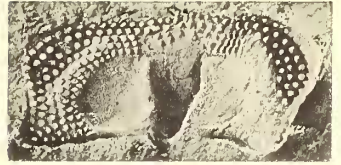
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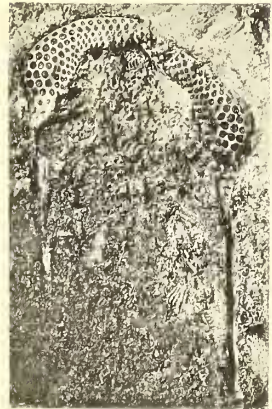
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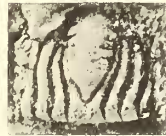
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4



18



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24



23



11



25

Marrolithus inflatus maturus Williams

Plate 117, fig. 4

1948 *Marrolithus inflatus* Williams, p. 74, pl. 6, fig. 3, text-fig. 4.1948 *Marrolithus inflatus maturus* Williams, p. 75, pl. 6, fig. 4, text-fig. 5.1956 *Marrolithus inflatus* Williams var. *maturus* Williams; Whittard, p. 56, pl. 7, figs. 2-4.

Material. Three well-preserved brims with parts of the genal spines, and one less well-preserved brim.

Locality. SJ 12272807, 80 yards north of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Description. *Cephalon*: border outline smoothly convex anteriorly from one antero-lateral corner to the other, more sharply convex at corners and slightly concave laterally, passing back into very long and straight genal spines. Glabella and cheeks not known. Brim flat anteriorly, swollen antero-laterally and gently concave between these corners and cheeks; flat laterally so far as can be seen. Fringe formula: E_1 1-22, e_{10} , I_1 1-20, I_2 1-19, I_3 3-18, I_4 5(6)-17 + I_5 8-17, I_6 13-17 and I_7 present in the antero-lateral corners. The swollen areas include I_1 11-16, I_2 12-16, I_3 14-15; hexagonal patterns of tubercles occur round largest pits. Angulation occurs at 15 or 16.

Thorax and pygidium: not known from the Berwyns.

Remarks. The pitting of the brims of the Berwyn specimens compares closely with the holotype (GSM 75220), but the swollen pits in I_4 mentioned by Whittard in the Shelve material were not present, either in this material or in the holotype. *M. inflatus maturus* is distinguished from the much commoner *M. favus* in the Berwyns on the basis of the outline of the cephalon, which is more strongly convex anteriorly in this variety.

Marrolithus favus (Salter)

Plate 117, figs. 5-11

1848 *Trinucleus ornatus* var. δ *favus* Salter, p. 350, pl. 9, fig. 3.1948 *Marrolithus favus*; Williams, pp. 70-73, pl. 6, fig. 9, text-fig. 2.1956 *Marrolithus favus*; Whittard, pp. 55-57, pl. 7, figs. 6-13, text-fig. 4.

Material. Some 250 cephalata and a much smaller number of pygidia attributed to this species. Thorax not seen.

Localities. Known from all three inliers, but particularly common in the Iwrch Valley Inlier at SJ 12272807, 80 yards north of Nant; and SJ 12172815, 200 yards north-north-west of Nant, 1 mile north of Llanrhaidr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Limestone, and Calcareous Shale.

Description. *Cephalon*: outline subrectangular, anterior border almost straight across, but slightly convex forward in mid-line and towards antero-lateral corners. Antero-lateral corners strongly convex; lateral margin slightly concave, sloping slightly inwards and backwards; posterior margin almost straight across, slightly convex backwards laterally and behind glabella; postero-lateral corners almost right angles, only slightly rounded. Glabella strongly convex longitudinally and transversely; tapering posteriorly,

with one pair glabellar furrows in front of occipital furrow; these quite short, narrow, inclined backwards. Glabella invades fringe only slightly, front of it approximately level with angulation of antero-lateral corners. Axial furrows moderately shallow, ending forwards in fossulae. Cheeks moderately convex longitudinally and transversely with shape of quarter circle, bent down most sharply at back. Posterior border narrow, passing laterally into back of fringe. Occipital ring narrow and bearing a small occipital spine. Fringe or brim flat in front and postero-laterally, swollen in antero-lateral corners and moderately concave between these swellings and cheeks. Fringe formula of a typical example: (A 46901) E_1 0-25, e_1 i, I_1 0-25, I_2 0-22+, I_3 2-22, I_4 6-23, I_5 9-20, I_6 14-16, I_7 laterally; angulation at 16; swollen area I_1 11-20, I_2 11-17, I_3 13-16, which equals 10, 7, and 4 respectively in the I_1 , I_2 , and I_3 rows.

Remarks. As Whittard (1956, p. 56) has pointed out, the precise delimitation of the swollen area is difficult, and counts will vary from one specimen to another. Hexagonal patterns of tubercles occur round the larger of the swollen pits. There is some variation in the pattern of the pits near the mid-line especially in the E_1 row and the two specimens quoted below illustrate this. Only the first part of the fringe formula is quoted for these; they should be contrasted with specimen A 46901 quoted above.

A 53015, E_1 1-24, e_1 o, i, I_1 0-24, &c., see Plate 117, fig. 7.

A 53016, E_1 0-26, e_1 i, I_1 0-25, &c., see Plate 117, fig. 8.

The strongly marked girder on the ventral surface of the fringe referred to by Whittard (1956, p. 56) seems to be not uncommon. A specimen from the Berwyns shows the fringe to be concave in front of and behind the anterior part of the girder. The girder decreases in prominence laterally and is hardly noticeable at the swollen corner or laterally, although there is a sharp drop from the I_1 pits to the E_1 pits in the swollen corners. This sharp drop is commonly seen on the dorsal lamella. The swollen area has the following formula; I_1 7 or 8-18, I_2 11-18, I_3 14-17, that is, 11, 8, and 4 rows, which is very similar to the formula of the dorsal lamella given above.

A single specimen (A 53017a) of this variety showed the most unusual phenomenon of incipient development in the antero-lateral corners of E_2 pits (Pl. 117, fig. 9). Three of these are present, in the row containing the angulation and the two rows in front. There is no trace of E_2 development in front of the glabella as in *Costonia*. Only one specimen showing this type of aberration was collected by Williams in some 1,500 specimens from the Llandeilo of Llandeilo. In it only one E_2 pit was developed though in a similar position. It may be noted that this aberrant specimen from the Berwyns has the sharply angulated antero-lateral corner of the type seen in *M. scalpriformis* Whittard, but the amount of brim outside the E_1 pit row is greater in this specimen.

Pygidium: breadth/length: 1.5/8.0 mm. on one specimen and 2.0/6.5 mm. in another. Nine or ten axial rings, of which the anterior is more prominent; axis tapers gently to posterior margin, where it is rounded, standing high above pleurae; moderately convex transversely. Pleurae flat, rising slightly laterally; no segmentation can be seen in internal moulds, external moulds reveal weak traces of at least three pleurae with space for several more. A low, narrow brim round margin of pygidium, beyond this, pygidium bent down into a vertical flange which is deepest behind axis and decreases laterally.

Remarks. In both the Llandeilo and the Shelve areas *M. favus* occurs in the highest beds

of the Llandeilo and both Williams (1948, p. 87) and Whittard (1956, p. 57) believe that it may be taken as a good index fossil for beds of this age. It is chiefly on the very great abundance of this species that the Llandeilo rocks of the Berwyns have been placed in the Upper Llandeilo. The pygidia described above are attributed to *M. favus* because this is the most abundant marrolithid species in the Berwyns, but they have not been found attached to the remainder of the exoskeleton. There is little variation in the pygidium between most species in the genus.

Marrolithus magnificus sp. nov.

Plate 117, figs. 1-3

Derivation of name. Latin *magnificus*, noble or fine; referring to the unusually great development of the swollen areas on the brim, this species having the largest swellings so far described on the brim.

	<i>Length</i> <i>mm.</i>	<i>Breadth</i> <i>mm.</i>
<i>Holotype.</i> A 46902, Plate 117, fig. 1. External mould of part of cephalon	8	20 est.
<i>Paratypes.</i> 1. A 53013, Plate 117, fig. 2. External mould of part of cephalon	11	26 est.
2. A 53014, Plate 117, fig. 3. External mould of part of cephalon	9	20 est.

Material. Six large fragmentary cephalons.

Type locality. SJ 12852846, 730 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llanrhaidr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Diagnosis. With subrectangular outline and the swollen areas extending deep into the I_4 row of pits.

Description. *Cephalon:* outline subrectangular; anterior border slightly convex forwards centrally, more strongly so in antero-lateral corners, with a slight concavity between; antero-lateral corners quite sharply angular, though paratype 3 shows them in a rounded condition; sides slope slightly inwards and backwards to genal angles; posterior border not unlike anterior in being convex backwards centrally and postero-laterally and slightly concave between. Genal angles 90° approximately. Glabella pyriform, strongly convex longitudinally and transversely; whether any glabellar furrows are present is unknown because of poor preservation; anteriorly glabella does not invade brim to any great extent; ends a little farther forward than a line joining antero-lateral angulations. Axial furrows broad, shallow, throughout, with small fossulae. Occipital furrow and ring poorly preserved. Cheeks more strongly convex longitudinally than transversely, most strongly bent down posteriorly, approximately a quarter circle in outline. Brim (dorsal lamella) narrowest in front, broadening to a maximum antero-laterally, narrowing again behind this to pass behind cheeks almost half-way to axial furrows; flat except in swollen areas. Fringe formula E_1 0-24, e_1 0, I_1 1-24, I_2 1-23 or 24, I_3 3-22+, I_4 5-18+, I_5 8-17+, I_6 13-17+, and I_7 may occur in the corners. Beyond row 17 regular arrangement of pits lost inside I_2 ; therefore, termination of I rows inside I_2 not known with any accuracy. Angulation at row 15. Swollen area: holotype I_1 8-17, I_2 9-17, I_3 10-16, I_4 14-

16, i.e. 10, 9, 7, 3. Two other specimens gave the counts 10, 8, 6, 4 and 12, 9, 7, 4 respectively. There is clearly a slight variation in pattern, but it falls within reasonable limits. Tubercles in hexagons round larger swollen pits as in most other species. In conjunction with very great swelling in corners, I_1 row stands high above E_1 row of pits there.

Thorax and pygidium: not known.

Remarks. This new species occurs principally at one locality high in the Calcareous Shale division near the top of the Llandeilo. It occurs on the same bedding plane as the much commoner *M. favus*, and it seems likely that they are closely related, this species probably having descended from *M. favus*.

Marrolithus lirellatus sp. nov.

Plate 116, figs. 17-20

Derivation of name. Latin *lirella*, a ridge, from the narrow swollen areas on the brim, where the great majority of the swollen pits lie in a single row.

	<i>Length</i> mm.	<i>Breadth</i> mm.
<i>Holotype</i> . A 53012, Plate 116, fig. 18. External mould of part of cephalon	7	16 est.
<i>Paratypes</i> . 1. A 46906, Plate 116, fig. 17. Incomplete cephalon showing ventral lamella	7	18 est.
2. A 46907, Plate 116, fig. 19. Internal mould of cephalon	6	14

Material. Twenty-five cephalons, many of them fragmentary.

Type localities. Holotype from SJ 07292634, 100 yards north-north-east of Llwyn-Onn Farmhouse, 3 miles west of Llanrhaiadr-ym-Mochnant; paratypes 1 and 2 from SJ 12272807, 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Limestone, and Calcareous Shale.

Diagnosis. Swollen area of the brim with eight to ten swollen pits in I_1 row and usually two or less in the I_2 row; angulation of the brim level with one-third way back on the glabella; the genal angle behind the level of the occipital ring. Radial pit rows very regular.

Description. *Cephalon*: outline gently convex anteriorly, broadly rounded antero-laterally, sides straight and slightly convergent backwards; posterior margin runs straight out from occipital ring before swinging more backwards to genal angle. Genal spines variable, may point backwards, downwards, and/or outwards, sometimes being curved. Glabella clavate, strongly convex longitudinally and transversely, protruding slightly into brim; one pair glabellar furrows, little more than pits near base of glabella. Axial furrows broad and with broad, shallow fossulae, separated from brim by gently convex, low, transverse ridge. Axial furrows pass into small pits at junction with occipital furrow. Occipital ring simple, consisting mainly of base for short, thick, nuchal spine pointing backwards and upwards at about 45° . Occipital furrow shallow except at pit at junction with axial furrows, continued laterally by posterior border furrows to brim behind cheeks. Cheeks gently convex longitudinally and transversely and a quarter ellipse in outline. Brim broadens gently laterally to angulation and beyond

to genal angle; gently concave out to girder, beyond which it drops away gently. Holotype fringe formula: E_1 0–25 or 26, e_i , I_1 , 2 , and 3 1–25, I_4 4–24, I_5 13–20; swollen area I_1 12–18, I_2 18. Angulation at 18. Other specimens show that angulation may also occur at either 17 or 16. Paratype 2 and another specimen show swollen area to extend from I_1 11–17 and I_1 11–18 respectively and in both cases there are no swollen pits in I_2 row. In the ventral lamella the girder is very prominently developed, especially in front of the glabella, where it consists of a sharp ridge. The brim is more strongly concave on the proximal side of the girder than is the case on the dorsal lamella. The swollen area in paratype 1 (A 46906) has the following formula I_1 8–17, I_2 14–16, that is, 10 and 3 pits. Other specimens showing the ventral lamella indicate that there are more pits in the swollen area than occur in the dorsal lamella. The regularity of the radial rows of pits is present in both the dorsal and ventral lamellae.

Remarks. This species seems to bear out Whittard's (1956, pp. 56 et seq.) observations on the greater development of the girder on the ventral lamella of marrolithid brims. There are some resemblances to *M. bureaui* (Oehlert), particularly in the extent and nature of the swollen area in the brim. In both species there is a long row of swollen pits in I_1 with few in I_2 , but the posterior margin of this species does not run forward to the genal angle and the angulation in the antero-lateral corners is less far forward. None of the Shelve or Llandeilo species bears a close resemblance to *M. lirellatus*. This species differs from *M. craticulatus* Whittard in having the largest pits in I_1 , from *M. arenarius* Whittard in not having large numbers of auxiliary pits in E_1 , and from *M. bilinearis* Whittard in having only one row of swollen pits.

Genus MARROLITHOIDES Williams 1948

Marrolithoides cf. *arcuatus* Whittard

Plate 116, fig. 21

1956 *Marrolithoides arcuatus* Whittard, p. 64, pl. 8, figs. 16–17, pl. 9, figs. 1–2.

Material. One external mould of an almost complete cephalon.

Locality. SJ 12272807, 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Description. *Cephalon:* anterior margin uniformly curved, convex forward; lateral margins almost parallel, converging slightly backwards; antero-lateral corners obtusely rounded; posterior margin runs straight out from mid-line before bending slightly backwards and outwards to genal angle.

Glabella pyriform, without glabellar furrows, although there is a slight pit on one side that might be a glabellar pit or might be due to crushing of the specimen. Axial furrows straight, converging backwards, with fossulae separated from brim by low ridge; posteriorly they drop into shallow pits at junction with occipital furrow. Cheeks rounded; much lower than glabella and dropping sharply into axial furrows and posterior border furrows. Occipital ring gently curved longitudinally, with a substantial occipital spine pointing upwards and then backwards. Occipital furrow very shallow, passing laterally into slightly less shallow posterior border furrows.

Brim widest in antero- and postero-lateral corners, narrowing in front of glabella and dying out behind cheek, lobes, reaching only a short way towards axial furrows. Girder most prominent antero-laterally, slightly less prominent anteriorly, and weak laterally. Inside girder radial ridges between pits more prominent than concentric ones. Fringe formula: E_1 0-22, I_1 1-22, I_2 3-22, I_3 4-21, I_4 5-17, I_5 10-17. Angulation at 15. In antero-lateral corners there is a concentric row of small pits not corresponding to radial rows farther out, and extending from rows 15 to 22. Increase in pit size outwards very slight, I_1 pits being only slightly larger than rest.

Thorax and pygidium: not known from the Berwyns.

Remarks. The specimen from the Berwyns differs from the Shelve material in the following respects. It is half as big again, the I_5 pits appear rather sooner, the girder is low laterally, the glabella invades the border to a greater extent, and this is reflected in the pit formula in the points at which the I_2 and I_3 rows begin. In *M. simplex* Williams there are fewer concentric rows of pits, while *M. simplex elevata* Williams has the I_1 row of pits markedly raised above the E_1 and I_2 rows. This specimen occurs rather earlier in the Ordovician than the type material, which comes from the *N. gracilis* Zone Rorrington Beds of Shropshire.

Marrolithoides sp.

Plate 116, figs. 15, 16

Material. Ten incomplete cephalae.

Locality. Commonest at SJ 12272807, 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Description. *Cephalon*: parallel-sided and straight across front, broadly rounded antero-lateral corners and roughly right-angled postero-lateral corners; posterior margin approximately straight across as far as can be seen, but bent slightly back to genal angles. Genal spines continue line of lateral margins straight backwards. Glabella clavate, dropping steeply to brim, posterior unknown; axial furrows broad with fossulae just behind brim. Cheek lobes gently convex, lower than glabella, almost semicircular in outline. Occipital ring narrow, with nuchal spine, occipital furrow narrow, passing into a small deep pit at junction with axial furrows; continued laterally by posterior border furrows. Border narrowest anteriorly, broadening through antero-lateral corners to postero-lateral corners where widest, beyond this narrows rapidly behind cheek lobes to die out about half-way to axial furrows. Slightly concave on proximal side of girder. Only slight increase in size in brim pits outwards, most marked in antero-lateral corners. Girder is well marked on dorsal lamella. Fringe formula: E_1 1-26, I_1 1-27, I_2 1-26, I_3 3-24, I_4 4-21, I_5 11-21, I_6 16-20. One specimen showed eight accessory pits in I_7 position between 14 and 19. Angulation varies between 16 and 18. Ventral lamella; in this species, too, girder very prominent in front of glabella, continues to be so to angulation then fades away to posterior, prominent again on genal spine. Otherwise similar to dorsal lamella.

Remarks. This rather motley collection of material lacks the sharply defined angulation seen in *M. arcuatus* Whittard and has a more uniform breadth to its brim. It also has

more concentric rows of pits. Similarly, there are more concentric rows of pits than in *M. simplex* Williams. The outward increase in size of pits in the best preserved brim is not believed to justify placing this material in *Marrolithus* and indeed it is not present in the majority of the specimens. Probably more than one species is present.

Family ENCRINURIDAE Angelin 1854
 Subfamily CYBELINAE Holliday 1942
 Genus ATRACTOPYGE Hawle and Corda 1847
Atractopyge sedgwicki sp. nov.

Plate 117, figs. 17, 18

Derivation of name. After Prof. Adam Sedgwick, famous for his work on the geology of North Wales.

	<i>Length</i> mm.	<i>Breadth</i> mm.
<i>Holotype.</i> A 46897, Plate 2, figs. 17, 18. External mould of cranidium	6	7 between eyes

Material. One cranidium.

Type locality. SJ 12852846, 730 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llan-rhaiadr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Diagnosis. Glabella expanded forwards, with two pairs of tubercles on the anterior lobe; anterior border with eight coarse tubercles at the front and one pair laterally; anterior border furrow deep, transverse, mesially; faint laterally.

Description. *Cranidium:* glabella gently arched transversely at front, more strongly convex behind anterior lobe; weakly convex longitudinally. Axial furrows broad and shallow, almost parallel at back, diverging forward gently at first before swinging outwards sharply behind swollen frontal lobe to end in fossulae. Glabella has two pairs of prominent tubercles on frontal lobe at corners of square, another pair of tubercles lies closer together and between second and third glabellar furrows. Glabellar furrows short and transverse, posterior pair are not quite transverse, broaden inwards giving subtriangular posterior glabellar lobes, second pair parallel to posterior margin, anterior pair reduced to pits slightly elongated laterally; furrows almost obsolete laterally, deepening abruptly into transverse apodemes proximally. The fossulae lateral to and just in front of the anterior glabellar furrows, slightly elongated along axial furrows. Anterior border transverse with flattened cylindrical shape mesially, with eight coarse tubercles on dorsal surface and a number of finer ones towards front; laterally it is cylindrical, lower, inclined backwards at about 45°, smooth except for one isolated tubercle on each side lying a short distance in front of fossulae. At tubercle, anterior border more swollen again though still smaller than anteriorly. Narrows behind tubercle, becomes almost parallel to axis of glabella and dips down into fossulae. Pre-glabellar furrow deep, transverse, mesially; oblique, shallow, almost dying out laterally, but continuing as far as the fossulae. Occipital ring arched transversely, moderately flattened longitudinally, about twice as long in mid-line as adjacent to axial furrows; occipital furrow shallow, deepening towards axial furrows. Fixed cheeks rise steeply

from axial and posterior border furrows, slightly higher than glabella, much higher than posterior border; palpebral lobes rise high above cheeks, lie between posterior and second glabellar furrows, equidistant from posterior margin and axial furrows. Posterior border low, straight, and simple; posterior border furrow well developed behind fixed cheeks, parallel to posterior margin. Facial sutures run straight forward from eyes to just outside fossulae, but course of posterior branch is unknown.

Remarks. This species differs from *A. kutorgae* (Schmidt) in having a different pustule pattern on the preglabellar field, while the eyes lie slightly farther back. Compared with *A. vardiana* Männil, the glabella is broader, the axial furrows are shallower, the eyes lie farther from the axial furrows, the apodemes are deeper proximally, the preglabellar furrow is faint laterally and the pustule pattern on the preglabellar field is different. *A. sedgwicki* differs from *A. grewingki* (Schmidt) in the following respects; the axial furrows are arcuate instead of straight and the frontal lobe of the glabella is more swollen; there are more tubercles on the anterior border and the anterior border furrow is deeper mesially. A single cranidium from Nantgaredig, Carmarthenshire, JP 3821 of the Geological Survey collections, is similar. From it *A. sedgwicki* differs in not having a prominent pustule in the preglabellar furrow, in having coarser ornamentation, eye ridges are absent and the glabella is less swollen transversely, though this last point may be due to crushing.

Atractopyge williamsi sp. nov.

Plate 117, figs. 12–16; Plate 118, figs. 1–7

Derivation of name. Named after Prof. Alwyn Williams of Queen's University, Belfast.

	Length mm.	Breadth mm.
<i>Holotype.</i> A 53028, Plate 118, figs. 5, 6. Internal mould of cranidium	3.5	9.5 (crushed)
<i>Paratypes.</i> 1. A 53027, Plate 118, fig. 4. Internal mould of cranidium	3.0	4.0+ (crushed)
2. A 53025, Plate 118, figs. 1, 2. Internal mould of cranidium	3.5	7.0 est.
3. A 53029, Plate 118, fig. 7. Internal mould of cranidium	4.0	9.0
4. A 53020, Plate 117, fig. 12. External mould of pygidium	1.5	2.0 (longitudinally compressed)
5. A 46896, Plate 117, figs. 14, 15. External mould of pygidium	3.0 est.	3.5
6. A 46895, Plate 117, fig. 16. External mould of pygidium	3.0	3.1
7. A 53021a, Plate 117, fig. 13. Internal mould of pygidium	4.0	4.2

Type localities. Holotype and paratypes 3, 5, 6, and 7 from SJ 12272807, 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant; paratypes 1, 2, and 4 from SJ 12171815, 200 yards north-north-west of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Diagnosis. With inflated, strongly convex glabella and very reduced anterior border.

Description. *Cephalon:* semicircular, breadth rather more than twice length, genal

angles bearing small fixigenal spines. Glabella strongly convex, pyriform, with bulbous anterior lobe dropping vertically or even overhanging at front; remainder of glabella strongly convex, lower than anterior lobe but merging with it, descending almost vertically to axial furrows, widening slightly across posterior glabellar lobes. Three pairs glabellar furrows, none crossing glabella completely. First two pairs very short, little more than pits, third pair longer, inclined backwards and inwards, partly cutting off very small, low, third glabellar lobes. Occipital ring slightly longer in mid-line than at sides, smooth. Anterior border discontinuous, starting as faint smooth ridge from axial furrows and dying out before reaching mid-line. Preglabellar furrow weak and shallow where present. Axial furrows run obliquely back behind anterior glabellar lobe at 30° to long axis, then swing round until parallel with it at third glabellar furrows, then swing outwards past third lobes to enter marked pit at junction with occipital furrow. Fixed cheeks strongly convex, rising steeply from axial furrows, about same height as posterior part of glabella with palpebral lobes at highest point level with second glabellar lobes; about two and a half times width of posterior part of glabella, bent down strongly to sides, dropping steeply to posterior border behind palpebral lobes, though only level with posterior border laterally. Posterior border short adjacent to occipital ring, but lengthens laterally to about twice length of occipital ring at genal angle, where it swings forward before being cut off by facial suture. Genal spine short, tapering at about 40° with outer margin parallel to long axis of glabella. Facial sutures proparian; anterior branches run forwards and outwards at 45° until level with first glabellar lobes, when they swing inwards to the axial furrows and anterior border. Posterior branches run parallel to posterior margin until almost half-way to border before curving slightly backwards to cut lateral margin a short distance in front of genal angle. Ornamentation of coarse tubercles on glabella and fixed cheeks, surface otherwise smooth. The pattern of these seems to be as follows: there is a transverse row of tubercles round the front of the glabella and low down, but on the remainder of the anterior lobe of the glabella they are scattered irregularly. A pair of tubercles is situated between each pair of glabellar lobes. On each fixed cheek there are three tubercles between the eye and the axial furrows, one a short distance in front of the eye, a second just behind it, and the third overhanging the posterior margin.

Pygidium: almost square outline, rounded in front, with slightly sigmoidal sides. Axis with eleven or twelve rings, at first almost parallel-sided, tapering gently until near posterior end, where it tapers sharply to end in a point cut off from the posterior margin by fourth pleurae, which swing round behind axis to meet just in front of posterior margin. Axial rings raised above level of pleurae, axial furrows well defined. First four axial rings completely separated by furrows, remainder by incomplete furrows seen only at sides and not crossing axis. Four pairs of pleurae, one pair arising from each of first four axial rings. These are raised, sharply defined, and with the exception of one specimen smooth, narrowest at front and broadening backwards. At first inclined outwards and backwards from axial rings, become parallel to long axis, then converge towards a point behind posterior end of axis before becoming parallel again. End in upturned points along straight posterior margin with fourth pleurae highest and immediately behind axis, and first pleurae lowest and farthest out, second and third pleurae in intermediate positions. Pleurae divided into narrow anterior bands and swollen posterior bands by

pleural furrows. These shallow throughout, long on first pleurae, shorter on second, only just present on third, and absent from fourth. Under points, posterior margin of pleurae drops almost vertically as doublure, still showing divisions into pleurae. Lower margin of doublure curved, being highest behind axis and lowest behind first pleurae, continues forward for a short distance along side of first pleurae. Whole surface faintly granular, almost smooth with the exception of one specimen (paratype 7) carrying a few tubercles on the pleurae.

Remarks. The cranidium resembles that of *Oedicybele* Whittington, but can be distinguished from it in having the eyes much farther back and much nearer the axial furrows. The pygidium differs from that of *A. kutorgae* (Schmidt) in the form of the doublure and in having fewer rings in the axis. It differs also from the pygidium of *A. grewingki* (Schmidt) in having a wider axis with fewer rings and having the pleurae reach farther back. The pygidium of *A. williamsi* is also unusual in having very narrow anterior bands on the second and third pleurae.

Family CALYMENIDAE Burmeister 1843
Subfamily CALYMENINAE Burmeister 1843
Genus FLEXICALYMENE Shirley 1936
Flexicalymene cambrensis (Salter)

Plate 117, figs. 19–24

1865 *Calymene cambrensis* Salter, pp. 98–99, pl. 9, figs. 12–14.

1931 *Calymene cambrensis* Shirley, pp. 20–22, pl. 1, figs. 11–15.

Material. Sixty cranidia, thirty pygidia, and one hypostoma.

Localities. Present in the majority of outcrops of Llandeilo rocks, but particularly common at the following localities: SJ 07292634, 100 yards north-north-east of Llwyn-Onn Farmhouse, 3 miles west of Llanrhaidr-ym-Mochnant; SJ 12172815, 200 yards north-north-west of Nant, 1 mile north of Llahraiad-ym-Mochnant; SJ 12582848, Quarry 450 yards south-south-west of Pen-y-graig, $1\frac{3}{8}$ miles north of Llanrhaidr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Ash, Limestone, and Calcareous Shale.

Description. *Cranidium*: arched transversely, less convex longitudinally but bent down fairly sharply in front. Glabella almost parabolic though rather flattened across front, not projecting as far forward as fixed cheeks, with weak median ridge seen only in well-preserved specimens. First (p) glabellar lobes (basal) almost quadrangular, slightly wider than axial part of glabella that lies between them and to which they are attached by low, narrow necks. Basal glabellar furrows deep, running at first in and backwards at 70° to long axis of glabella before bifurcating; anterior branch very short, shallow, swinging slightly forward and dying out; posterior branch, turning back until about parallel to long axis of glabella, remains deep until it reaches occipital furrow cutting off glabellar lobe, no intermediate lobes on even largest specimens. Second glabellar (p) lobes well developed, elongate, inclined at 60° – 70° to long axis; do not project as far to side as basal pair, cut off from median part of glabella by low necks that are less prominent than those behind. Second glabellar furrows (p) broader, less deep, almost parallel to first, bending slightly back before dying out on neck of second lobes. There is a faint suggestion of an anterior branch to this furrow turning slightly forward and dying out. Third glabellar

lobes (p) small, inclined slightly back and in, nearly at right angles to axis, much lower than median part of glabella, with weak neck separating them from it. Third glabellar furrows (p) short, shallow, almost at right angles to axis, inclining slightly backwards. Very faint fourth glabellar furrows (p) in front of this, barely discernible and leaving axial furrows just behind fossulae. Anterior lobe of glabella semicircular, rather straight across the front. Axial furrows run forwards and outwards from occipital furrow, farthest apart across middle of basal glabellar lobes, then converge forward, deepest here also, become shallower forwards towards second glabellar lobes (p) before deepening slightly to fossulae; beyond this, shallower and broader before merging into preglabellar furrow; narrowest at middle of basal glabellar lobes, very gradually widen forwards. Preglabellar furrow shallow and, like the anterior border, which is unbroken and rises gently forward, is affected considerably by compression of individual specimen. Occipital ring about twice as long in mid-line as behind glabellar lobes, extends laterally not quite as far as first glabellar lobes; about same height as first glabellar lobes in mid-line and lower behind them; none of the Berwyn specimens showed the median knob seen in the types. Occipital furrow deepest behind glabellar lobes and shallower and broader in mid-line where it swings some distance forward. Fixed cheeks much lower than median part of glabella, palpebral lobes about same height as second glabellar lobes, which they are opposite; cheeks slope steadily outwards and downwards towards genal angles, gently convex longitudinally. Posterior border broadens steadily outwards from axial furrows to genal angles while bending gently backwards; at genal angle it begins to turn forward before being cut off by gonatoparian facial suture. Facial sutures run almost straight forward from eye to anterior border, posterior branches swing outwards and backwards to most posterior part of border furrow before cutting genal angle. Free cheeks not known.

Hypostoma: subquadrate outline, middle body ovate, uniformly swollen, middle furrow curved, crossing middle body to divide it into a U-shaped posterior lobe and an ovate, globose, anterior lobe. Lateral border separated from middle body by broad lateral furrow running from anterior wing, where narrow, back parallel to border and broadening out to posterior wing where deepest; here, lateral furrows merge into posterior furrow, also broad. Anterior margin ventrally flexed centrally and slightly convex forward; anterior furrow broad, shallow. Anterior wings small, gently flexed dorsally, slightly backwards. Posterior wings obtusely pointed, lying about two-thirds way back. Posterior forks acutely rounded on either side of median notch, which extends forward to cut posterior furrow.

Pygidium: almost diamond-shaped outline, strongly convex transversely, nearly flat longitudinally, bent down sharply beyond tip of axis. Eight axial rings and short unsegmented portion beyond, seven pairs of pleurae. Axis three-sevenths of width at front, narrowing rapidly for first four rings then more gently to posterior part of axis; strongly arched transversely, anterior rings flattening out towards axial furrows. Ring furrows become shallower backwards, all crossing axis; articulating half ring present. Axial furrows deepest opposite fifth axial ring, become shallower backwards and forwards, unite at tip of axis, which does not quite reach posterior margin. Pleurae strongly convex, bent down most strongly at posterior, becoming more flattened distally; pleural furrows faint, but extending from axial furrows to margin, dividing pleurae into slightly

larger anterior and smaller posterior portions; interpleural furrows well developed. Pleurae behind sixth pair ill defined but space for a further two pairs before mid-line in post-axial area. Margin of pygidium rises posteriorly to almost meet tip of axis. Laterally bent down.

Remarks. This material corresponds closely with the description of the species by Shirley (1931). The anterior border is the area most meriting comment. Here it varies from one-third to one-quarter or even one-fifth of the length of the glabella, and so far as can be seen this figure depends chiefly on the amount of compression that the specimen has undergone, and the direction taken by that compression relative to the long axis of the specimen. Those compressed perpendicularly to the long axis have the longest anterior border (up to one-third length of the glabella) while those compressed along the length of the specimen have much shorter anterior borders. In the latter specimens the anterior border also takes on a slightly bent appearance producing a condition approaching that seen in the anterior border of *Reacalymene*. The break seldom goes as far as is seen in that genus, but the intermediate stages seem well represented. A more extreme condition of compression is illustrated alongside more normal specimens (Pl. 117, fig. 22).

The description of the pygidium is rather more detailed than that of Shirley, and the hypostoma is described for the first time.

Family LICHIDAE Hawle and Corda 1847
Subfamily LICHINAE Hawle and Corda 1847
Genus METOPOLICHAS Gürich 1901

Metopolichas contractus sp. nov.

Plate 118, figs. 8-17

Derivation of name. Latin *contractus*, narrow, from the narrow central lobe in the glabella.

	Length mm.	Breadth mm.
<i>Holotype.</i> A 46894, Plate 118, figs. 8-10. Internal mould of cranium	13	14 est.
<i>Paratypes.</i> 1. A 46893b, Plate 118, figs. 11, 12. Fragmentary internal mould of cranium	9.5+	9+
2. A 53030, Plate 118, figs. 13, 14. Internal and external moulds of hypostoma	4	5.5
3. A 53031, Plate 118, figs. 15-17. Internal and external moulds of pygidium	4.5	9

Material. Two incomplete cranidia, one hypostoma, and one pygidium.

Type localities. Holotype from SJ 12582848, 450 yards south-south-west of Pen-y-graig, 1 $\frac{2}{3}$ miles north of Llanrhaiadr-ym-Mochnant; paratypes from SJ 12272807, 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, Montgomeryshire.

Horizon. Upper Llandeilo, Calcareous Shale.

Diagnosis. Glabella with elongate and narrow central lobe which is lower than the bicomposite lobes at its narrowest point, and with occipital ring hardly extending beyond the occipital lobes; pygidium with axis dying out gradually and reaching well towards the posterior margin, which has a slight median embayment.

Description. *Cranidium*: gently convex transversely, strongly so longitudinally, anterior margin rounded and slightly arched in centre. Anterior border well defined continuing on to front of free cheek. Glabella, widest across bicomposite lobes; central lobe flattened posteriorly, curved downward in front; longer than wide, gently rounded transversely in front with acutely rounded antero-lateral extremities; greatest width of central lobe in front of bicomposite lobes, then narrowing posteriorly to about one-quarter of maximum width and parallel-sided about half-way back along bicomposite lobes; gently widening behind this so that between basal lateral glabellar lobes, from which separated by very shallow depressions, it is about half maximum width at anterior. Anterior of central lobe strongly convex longitudinally and transversely, downward slope to front starting from a level about half-way along bicomposite lobes; narrow neck gently convex longitudinally and transversely and slightly lower than bicomposite lobes; posterior part gently convex transversely and with an even slope backwards. Longitudinal furrows start at front of bicomposite lobes and lead inwards at right angles to length of specimen, then gradually curve backwards and converge until level with front of fixed cheeks where they are parallel to long axis. A short distance in front of the narrowest part of central lobe, the longitudinal furrows have slight notches on their outer sides; these represent relics of first glabellar furrows. Behind the narrowest part of the central lobe they gradually diverge to become the basal lateral furrows behind bicomposite lobes; these turn sharply outwards and, just before dying out, swing forwards, not joining axial furrows. Bicomposite lobes slightly kidney-shaped, semi-oval, rather broader at anterior end, which is bluntly pointed; about two and a half times as long as broad; moderately convex, posteriorly just coalescing with basal lateral glabellar lobes, almost cut off by basal lateral furrows. Basal lateral glabellar lobes quadrilateral, outline almost diamond-shaped, weakly marked off from base of central lobe and coalescing with bicomposite lobes. Occipital lobes almost triangular with side against occipital ring and two almost equal sides against fixed cheek and basal lateral glabellar lobe, all three being slightly convex outwards. Occipital ring longest between occipital lobes, slightly convex forwards; behind occipital lobes narrows to about half this length and bends gently round lobes; passes laterally for only a very short distance beyond occipital lobes, continued behind fixed cheeks, by posterior border, which it only just touches. Fixed cheeks long, narrowly pointed anteriorly extending forward half-way along bicomposite lobes, widening backwards with palpebral lobes lying level with basal lateral glabellar lobes; continuing backwards to occipital lobes, occipital ring and posterior border; not known completely. Axial furrows convex outwards to narrowest part of glabella then gently concave outwards as far as occipital lobes, then diverging strongly and skirting occipital lobes. Occipital furrow very slightly convex forward centrally, almost parallel to posterior margin, shallower and broader than other furrows, dividing laterally round occipital lobes with anterior branch also broad, shallow; posterior narrow and deeper until it joins axial furrow and broadens. Posterior border furrow broad and shallow as far as seen. Cheeks only partly seen. Posterior part of palpebral lobe separated from fixed cheek by a shallow broad furrow, concave outwards, which continues forward, becomes deeper and swings inwards to join axial furrow. Anterior part of free cheek also preserved, continues forwards as far as anterior of bicomposite lobes; remainder unknown.

Hypostoma: convex longitudinally and transversely, roughly polygonal in outline but

with indented posterior margin and rounded in front. Middle body about as long as wide, rounded in front, sides slightly divergent backwards, posterior margin gently undulating, almost straight across. Middle furrow incomplete, lying nearer posterior margin, consisting of a curved furrow on each side, converging posteriorly, but not joining in mid-line. Middle body ends sharply backwards at posterior furrow, which resembles middle furrow in consisting of two crescentic furrows, convex backwards, but these do join in mid-line making a slight forward notch in middle body. Lateral furrows broad and fairly deep, almost straight, parallel to long axis; appear from beneath anterior part of middle body and run back to middle furrow where they follow a slightly curved course, convex outwards, back to posterior furrow; beyond this flatten out with a posterior branch continuing on to posterior wing and a faint anterior branch passing outwards behind anterior wing. Anterior border if present is hidden, dorsal to front of middle body. Anterior wings rounded, raised sharply above lateral furrow, sloping more gently posteriorly and merging into much larger, flatter posterior wings, which are also rounded and with faint terrace lines; joined by posterior border, which is raised above their level, but which is not as high as posterior of middle body. Posterior margin straight across except for a central semicircular embayment of about half width of middle body.

Pygidium: semicircular in outline, almost exactly twice as wide as long. Axis about two-thirds length and anteriorly just under one-third breadth, tapers posteriorly, markedly raised above pleurae and with well-defined axial furrows which die out two-thirds way to posterior margin after diverging; posteriorly dropping to level of pleurae and flattening without a sharp termination. Marked anteriorly by two or three ring furrows, first strongly developed, second much less so, a possible third faintly developed behind that. Owing to preservation not known whether any or all of these furrows cross axis. Three pairs of pleurae occur, first being separated from second by sharp interpleural furrow, second from third by a weak interpleural furrow. Anterior pleurae are only slightly

EXPLANATION OF PLATE 118

- Figs. 1-7. *Atractopyge williamsi* sp. nov. 1, 2, and 4, From 200 yards north-north-west of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant. 1, 2, Normal and anterior views of A 53025, paratype 2, internal mould of incomplete cranidium, $\times 6$. 4, Side view of A 53027, paratype 1, internal mould of incomplete cranidium showing fixigenal spine, $\times 6$. Figs. 3 and 5-7, From 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant. 3, A 53026, internal mould of incomplete cranidium, $\times 6$. 5, 6, Normal and anterior views of A 53028, holotype, internal mould of cranidium, $\times 6$. 7, A 53029, paratype 3, internal mould of cranidium, $\times 6$.
- Figs. 8-19. *Metopolichas contractus* sp. nov. 8-10, From 960 yards north-west of Plas-yn-glyn, 1 mile north-north-east of Llanrhaiadr-ym-Mochnant, side, normal, and anterior views of A 46894, holotype, internal mould of incomplete cephalon, $\times 3$, $\times 2$, and $\times 2$ respectively. 11, 12, From 200 yards north-north-west of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant, normal and side views of A 46893a, paratype 1, internal mould of incomplete cranidium, $\times 3$. Figs. 13-17, from 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant. 13, Internal mould of A 53030a, paratype 2, hypostoma, $\times 4$. 14, External mould of A 53030b, hypostoma, $\times 4$. 15, A 53031a, internal mould of paratype 3, pygidium, $\times 3$. 16, 17, A 53031b, and plastic mould from A 53031b, external mould of pygidium, $\times 3$. 18, 19, Locality unknown, OUM B 122b, and plastic mould from OUM B 122b, external mould of pygidium, $\times 1.5$.
- Figs. 20, 21. *Dimeropyge* sp. from 80 yards north of Nant, 1 mile north of Llanrhaiadr-ym-Mochnant. 21, A 53032, external mould of pygidium, $\times 4$. 20, Plastic mould from A 53032, $\times 4$.